

## **PAN-AFRICAN MATERIALS INSTITUTE (PAMI)**

### **OF THE**

## **AFRICAN UNIVERSITY OF SCIENCE AND TECHNOLOGY (AUST) ABUJA**

The goal of the Pan African Materials Institute (PAMI) is to create and discover new materials for African development – “*Materials for African Development.*” We are developing African capacity to add value to materials and mineral resources within the Western and Central African regions and we are achieving our goal by our (1) Education, (2) Research and (3) Outreach activities

Africa is endowed with many natural resources but, unfortunately, Nigeria (and Africa as a whole) does not have a critical mass of experts who have the skills to harness these materials. At the same time, Africa currently exports natural resources with very little value addition, consequently receiving only a fraction of what we could possibly obtain for it.

In the area of Education, PAMI is coordinating the training of a critical mass of Africans through short courses and MSc/PhD degree programs that will be supplemented by state-of-the-art distance learning and lab access techniques. PAMI faculty and students are also engaging in interdisciplinary and transdisciplinary research that address African needs in health, energy, water and affordable housing/infrastructure. These regional research efforts are carried out in close association with PAMI collaborators at international world class labs/universities. Our plan is to have PAMI faculty and students visit those collaborators in the USA, Europe and Brazil to engage in advanced research and training. The visiting faculty and students will return to West and Central Africa to use their knowledge to strengthen the efforts of PAMI. PAMI will also organize short courses for the training of industrial personnel, policymakers and academics at other universities and research labs. The regional outreach efforts include special program for Women in Science and Engineering (WISE) and programs that will introduce middle and high school students to key concepts in materials science and engineering. PAMI faculty and collaborators include women in academia and a strong women-driven teaching and recipient focus is included in the programs. All programs are coordinated by a PAMI secretariat that will work closely with the PAMI Executive Committee (PEC), a Materials Industry Advisory Board (MIAB), National/Regional sub-committees and Regional Focused/Seed Research Groups. The PAMI secretariat administers questionnaires and evaluation forms that measure the impact and effectiveness of the proposed programs. It also works closely with the PAMI Executive Committee to develop a demand-driven sustainability plan that will couple PAMI’s future to the needs of African Industry.

### **PAMI PARTNERS**

PAMI has twenty-one (21) partners, including AUST:

1. Worcester Polytechnic Institute (USA)
2. University of Sao Paulo (Brazil)
3. Blaise-Pascal University (France)
4. Arizona State University (USA)
5. Ohio State University (USA)
6. Rutgers University (USA)
7. University of Buea (Cameroon)
8. Kwame Nkrumah University of Science and Technology (KNUST, Ghana)
9. University of Ghana
10. University of Lagos (Nigeria)
11. Kwara State University (KWASU, Nigeria)
12. Sheda Science and Technology Complex (SHESTCO, Abuja Nigeria)

13. Obafemi Awolowo University (OAU, Ile-Ife Nigeria)
14. National Agency for Science and Engineering Infrastructure (NASENI, Nigeria)
15. Nnamdi Azikiwe University (Awka, Nigeria)
16. African University of Science and Technology (AUST, Abuja)
17. Ahmadu Bello University (ABU, Zaria)
18. Stanford University (USA)
19. Tufts University (USA)
20. University of Cheikh Anta Diop (Senegal)
21. University of the Gambia

The last four on the list have not been particularly active in PAMI activities.

### **RESEARCH AND EDUCATION OUTPUT**

The program has made contributions to the study of the structure and the properties of materials for applications in transportation (aerospace/naval/automotive) systems, biomedical systems, energy systems, flexible electronic/micro-electro-mechanical systems and sustainable buildings. The research activities use a combination of materials science and mechanics to guide the development of materials for multifunctional applications. Our publications have also provided insights into the effects of structure on the properties of materials at different scales (from the nano- to the micro- and macro-scales). Our scholars are tooled to apply the materials science and engineering to solve practical human problems. The outcomes have thus shifted from just the production of highly trained scientists to problem solvers who can apply their knowledge to real-life problems

In collaboration with Materials Science and Engineering Department of the African University of Science and Technology (AUST) in Abuja, we have carried out research in three main areas. These come under the three Focused Research Groups (FRGs) of PAMI:

- Multifunctional Materials: Mineral Processing; Materials for Sustainable Infrastructure; Materials for Water Purification
- Materials for Energy (works closely with those in Energy Physics)
- Materials for Health (also called Biomaterials)

Under our multifunctional materials FRG, students, professors, and researchers have used fracture mechanics to develop new mechanism-based models for the prediction of crack growth in scenarios involving the growth of coplanar and co-linear elliptical cracks. These experiments provide new insights that enabled the development of mechanism-based fracture mechanics models for the prediction of interactions between multiple cracks, as well as the coalescence and growth of such cracks. These models, which were developed originally for pressure vessel steels that are used in ships and offshore structures are now being applied to study the failure mechanisms in concrete structures made of cementitious and earth-based ceramics. Some specific research output from these work include:

- a) Preliminary studies of materials for the processing of the mineral Barite (for use in mud fluid in the oil industry). We are negotiating to host a TOTAL Nigeria Limited research program in the large-scale processing and use of Barite in oil and gas recovery.
- b) surface hardening of steel using locally available waste products (Cassava waste for cyanidization)
- c) development of better building materials natural fiber-reinforced earth-based composites

- d) (improved) composite building materials using waste (polyethylene). This research is important for two reasons: i. better building materials are produced while at the same time, ii. Waste materials (used polyethylene) are removed from the environment.
- e) Development and characterization of clay ceramic materials for water filtration. The ceramic water filters have been shown to improve the health and wellbeing of people in rural villages in Nigeria and Kenya.

Other efforts in this FRG include corrosion studies and corrosion prevention research in oil and gas pipeline infrastructures, combined experimental and analytical/computational studies of the mechanical properties of titanium alloys/intermetallics, in-situ titanium matrix composites, fiber-reinforced titanium and ceramic matrix composites, nickel alloys, nickel aluminide intermetallics, niobium aluminides and niobium aluminide composites, and cellular materials. In each of these systems, the underlying mechanisms of fatigue and fracture were elucidated. Crack-tip shielding concepts were also used to develop guidelines for the microstructural design. These research efforts have yielded marketable graduates who are well sought after by industry world-wide, providing PAMI-ACE-AUST scholars world-wide mobility and highly skilled job placements. In Africa our scholars can be found doing important work in Nigeria, Tanzania, Ghana.

Our Materials for Energy FRG has focused on the processing and use materials science and engineering methods to develop different kinds of solar cells, including Perovskite solar cells (that are described as the light of the future) and organic light emitting devices (OLEDs). These research use pressure-assisted micro- and nano-fabrication techniques for the low cost processing of solar cells and light emitting devices; these are being integrated into smart building materials designs and plans are on the way to build such permanent structures on the AUST campus as a monument to the PAMI-ACE research efforts.

Specifically, we have research in the following areas:

- a) Pressure-assisted fabrication of organic light emitting devices
- b) Layered composite thin films for cost effective transparent organic solar cell electrodes
- c) Effects of adhesion and deformation on stretchable electronic structures
- d) Effects of surface texture and nanoscale surface oxides on the optical and mechanical properties of silicon single crystals and MEMS thin films

In our Materials for Health FRG, students, professors, and researchers have developed ligand-conjugated magnetite nanoparticles (derived from iron ore deposits) that attach specifically to breast cancer cells/tissue. The specific attachment has been used to enhance the magnetic resonance imaging of breast cancer cells/tissue. FRG-bio has also developed new drug/nanoparticle clusters and biomedical devices that can be used to shrink breast tumors via localized cancer drug delivery, thus linking primary mining and mineral processing to the highest levels of application in medical care. Specific research include:

- a) Implantable composite devices for the localized treatment of breast cancer – this involved using materials to design implants that can be release heat upon application of magnetic fields. These devices are attached near diseased organs in order to kill the diseased cells by locally heating the region.
- b) Implantable biomedical devices for localized breast cancer drug delivery – materials were designed and impregnated with a potential anticancer drug. These devices are attached near the diseased organs and the drugs can then be released locally which, in principle, will lead to higher efficacy and less side effects than the more common systemic/global chemotherapy.
- c) Nano- and micro-particles for breast cancer detection and treatment – nano and micro particles were synthesized and then functionalized. These functional groups can attach to cancerous cells and used for detection and/or treatment.

## **PAMI ACTIVITIES – 2015**

### **I. PAMI LAUNCH/ PASMAT WORKSHOP (PASMAT I)**

The Pan African School of Materials Institute (PAMI), one of the World Bank ACE projects was formally launched in November, 2015 at the host University- African University of Science and Technology (AUST), Abuja. The launch took place alongside the inaugural PASMAT workshop from 1<sup>st</sup> to 7<sup>th</sup> November with participants from various countries within and outside sub-Saharan Africa in attendance, private and public sector inclusive. Participants from academia, industry and government organizations had extensive interactions and deliberations on how to improve the quality of life for Africans by Africans through indigenous research with global perspectives. Some of PAMI's partner institutions that were in attendance are: University of Buea, Cameroon; University of Lagos, Nigeria; Kwara State University, Nigeria; Princeton University, USA; University of Ghana; National Agency for Science and Engineering Infrastructure (NASENI); Sheda Science and Technology Complex (SHESTCO); etc.

A total number of 136 participants (27 females and 109 males) were in attendance at the PAMI launch/PASMAT workshop.

### **II. PASMAT II**

From 6<sup>th</sup> to 11<sup>th</sup> December, 2015, PAMI co-hosted the African Materials Research Society (A-MRS) workshop at the University of Ghana. Special technical sessions were facilitated by PAMI on its three focused research areas. Of the 113 participants in attendance, 21 and 92 made up females and males respectively.

### **III. RESEARCH PULICATIONS**

PAMI recorded 78 research publications in internationally recognized, world class, scientific journals, a number of which at the time had an average of 3.0 impact factor.

### **IV. REGIONAL STUDENT ENROLMENT**

As at October 2015, PAMI had 45 regional students enrolled in its programs, all studying and conducting research in PAMI research focus areas at MSc and PhD levels.

## **PAMI ACTIVITIES IN 2016**

### **I. BIO-MATERIALS SHORT COURSE**

One of the first activities of PAMI during the year was the Bio-Materials short course which held at AUST, Abuja. A total of 17 participants were in attendance, 7 females and 10 males. The course held from 7<sup>th</sup> to 11<sup>th</sup> of March, 2016.

## II. PASMAT III

The Pan African School of Materials Workshop is a biannual workshop organized by the Pan-African Materials Institute (PAMI) to share research outcomes among partners as well as provide public education on the development capacity of higher educational endeavours. Research under PAMI is centered on three primary areas namely: Materials for Energy; Bio-Materials; and Multifunctional Materials. These are referred to as FRGs (Focused Research Groups).

The third edition of the workshop held from 11<sup>th</sup> to 15<sup>th</sup> of July, 2016 at the African University of Science and Technology (AUST), Abuja. A total of 248 participants were registered at the workshop. Details of participation at the workshop are outlined below.

FRG	Total no. of Participants	Male	Female	Nigerians	Non-Nigerians
Bio-Materials	43	28	15	35	8
Materials for Energy	40	34	6	34	6
Multifunctional Materials	70	60	10	10	60

## III. INTRODUCTION TO MATERIALS SHORT COURSE

The Introduction to Materials course is a prerequisite for PAMI students. This short course, taught by Professor W.O. Soboyejo, was organized from 11<sup>th</sup> to 29<sup>th</sup> July, 2016. Of the 36 participants in attendance, 14 and 22 made up the number of females and males, respectively. A total of 17 regional students from various countries including: Ghana, Liberia, Sierra Leone, Cameroon, Rwanda, took part in this course.

## IV. PAMI SCHOLARSHIPS

A total of thirty two (32) students were given PAMI scholarships at AUST. Four of the students were MSc students while the rest were PhD students in different fields at AUST but most of them had a materials-related research focus.

## PAMI ACTIVITIES IN 2017

Two activities from 2016 were postponed to 2017 due to a lack of sufficient funds at their planning stages. One of them was a planned PASMAT IV Workshop at the University of Buea, Cameroon, which would include a Women In Science and Engineering (WISE) outreach program to encourage young girls to take up Science, Technology, Engineering, and Mathematics (STEM) and, in particular, Materials Science and Engineering. Unfortunately, due to an unrest in that part of Cameroon, the program had to be postponed. We plan to hold it later in the year after the region is settled.

## I. PASET Initiative:

AUST was selected as a host institute in the PASET initiative in the focus area of Materials Science and Minerals Processing. This means, once the agreement is signed, PAMI/AUST will help train students from Rwanda and other parts of Africa in Materials Science and Minerals Processing. A number of negotiation meetings were held this year (2017).

## **II. Research Visit to Nigeria by PAMI Partners at the University of Buea, Cameroon.**

Five scholars from the University of Buea, Cameroon, visited Nigeria to carry out research (mainly characterization of their samples). They were led by the PAMI partner anchor person from the University of Buea. On this side (Nigeria), they were received by Dr. M.G. Zebaze Kana who is a PAMI lecturer, the leader of our Energy Focused Research Group, and a member of our PAMI partners at the Kwara State University (KWASU). Their stay was from the 25<sup>th</sup> of March to the 1<sup>st</sup> of April, 2017.

## **III. Procurement of Equipment for PAMI Partner at the University of Buea, Cameroon.**

The process of procuring equipment worth about \$30,000 for a PAMI Partner was carried out. The bid documents were prepared by our procurement officer, the bid response/submission evaluated and the contract has been awarded. We expect that in a few weeks the equipment will be delivered to the University of Buea, thus enhancing their research and educational capabilities.

## **IV. PAMI Scholarships: First Batch**

A first batch of students at AUST have been awarded 2017 PAMI scholarships. 23 students were included in this first batch. A second batch will follow shortly.